Fundamental Studies of Ion Cutting

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Through an ion cutting process, very high quality thin single crystal silicon layers can be transferred to other substrates to provide new and improved device capabilities in a variety of applications. This collaborative project addresses fundamental materials science issues of the ion cutting process related to layer cleavage and layer transfer in hydrogen implanted silicon (Fig.1).

After hydrogen ion implantation, a transfer wafer is bonded to the top Si layer which is cleaved for transfer to a new substrate, *i.e.,* the transfer wafer. Typically cleavage requires conventional thermal annealing at > 600°C. Using ion and x-ray analyses, cleavage was found to occur at the peak in the defect distribution rather than at the peak in the hydrogen distribution. The depth correlation with defects produced during the ion implantation is important in controlling layer thickness (100-1000 nm). A rapid thermal anneal or brief surface polish removes any residual surface damage associated with the cleave process. Figure 2 shows one of the many possible applications of the process with a high quality single crystal Si layer bonded to a flexible, light weight polymer substrate.

There has been a breakthrough in our project with successful implementation of low-temperature microwave heating that cleaves Si with a conventional microwave (MW) furnace. The significance of this achievement is that this new low temperature process results in high crystalline quality cleaved silicon layers that are bondable to many types of substrates that prior to this time have only been achieved with high temperature processing (>700°C). In addition to reduced processing temperatures and costs, MW processing enables integrated circuit fabrication of Si bonded on flexible polymer substrates that would typically not be used due to their low melting points. Using the MW cleave process, single crystal Si layers will provide higher mobility devices that are a factor of 10 faster than current devices formed using amorphous Si. This is expected to have a major impact in future commercial and military applications requiring light weight displays and electronics.

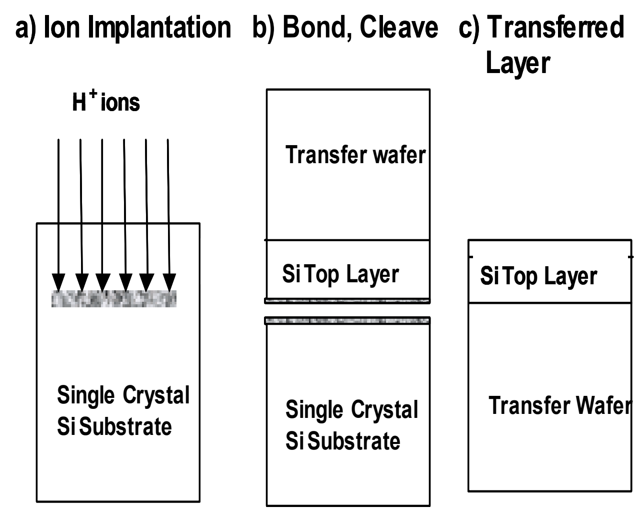

Fig. 1 Schematic drawings of the ion-cutting process

Fig. 2 Schematic diagram of a high quality single crystalline layer produced by the ion-cutting process with layer bonded to flexible polymer substrate. These substrate are proposed for future generations of large area electronics and displays.

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Research Education:

Gerald Malgas has completed his Ph.D. dissertation at the University of the Western Cape, South Africa, a Historically Disadvantaged University (UWC). This work was done while he was a visiting student at ASU under NSF support.

Profs. Alford and Mayer have worked with student organizations, faculty, and other institutions to recruit and mentor academically talented students, especially students from underrepresented groups. Profs. Alford and Mayer promoted and facilitated degree achievement at the Baccalaureate and eventually the MS and PhD levels: 4 female PhDs, 4 female MS students, 2 African-Americans, 4 Hispanics, and 4 international students from UWC. It should be noted that for the past ten years, our program at ASU includes at least one female student every year in the Ph.D. program, and at least one Hispanic in our MS and Ph.D. program every year.

The silver metallization studies supported by NSF Center for Low Power Electronics – (EEC-9523338) have been recognized by the award of graduate student, Hyunchul Kim, with the $3000 prize by The International Precious Metal Institute.

Dr. Terry Alford, co-PI was nominated for The MRS Medal for silver metallization based on activities from NSF supported research – DMR9624493.

Outreach:

Visiting Prof. Adams/U. Western Cape, SA promotes exchange research with remote controlled access to a four-point-probe furnace. Gerald Malgas has used the furnace by remote access at the U. Western Cape, SA, a Historically Disadvantaged University. D. Thompson, an ASU graduate student, observes.